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Investing in school readiness: A comparison of different early childhood education pathways in rural Indonesia

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ABSTRACT

This paper documents that children in rural Indonesia participate in a great variety of early childhood education pathways. Three key factors predict early education pathways: household wealth, mother's education, and the quality of available services. We also find that children who enrolled in playgroup programs at age 3–4 followed by kindergarten programs at age 5–6 scored significantly higher on primary school tests than those enrolled only in playgroup programs or only in kindergarten programs. This suggests that the sequence of these pathways is important for future learning. We also provide illustrative estimates of the cost-effectiveness of different pathways.

1. Introduction

International evidence shows that investing in high-quality early childhood programs can have large economic returns, especially for children from socially disadvantaged groups (Barnett, 2011; Engle et al., 2011; Walker et al., 2011; Yoshikawa et al., 2013). In response, developing countries are looking to increase public investments in early education programs (World Bank, 2016a). One of the challenges faced by policymakers is deciding what to fund given the wide range of programs that exist in local settings. As such there is considerable interest in understanding how children's various early education experiences predict their success as they transition into primary school.² This understanding is particularly pertinent to on-going policy discussions in Indonesia regarding how best to prioritize investments in pre-primary education to meet the Sustainable Development Goals.

Much of the existing literature focuses on whether a specific type of preschool is effective. However, the reality of children's early

educational experiences is more complex. We use rural Indonesia as an example to show that often multiple preschool options are available, that there is considerable heterogeneity in the sequence of early childhood education participation among children and argue that this matters in predicting children's success in primary school.

We use a uniquely rich dataset from Indonesia that provides children's entire enrollment histories in early education programs. The data were collected in 2013 and sampled nearly 13,000 children in 310 poor villages in Indonesia as part of an evaluation of the Indonesia Early Childhood Education and Development project. A second feature of the data is that we administered tests to these children when they were in the early grades of primary school. We focus on test scores in language, mathematics and general cognitive skills of children age 6 to 9.

First, we explore the extent to which families self-select into different sequences of early education programs. Second, we analyze how different sequences of early education programs correlate with primary school test scores. We show that children enrolled in playgroup

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² In this paper, "early education" and "early childhood education and development (ECED)" are used interchangeably and refer to the broad range of site-based early learning programs from age 3 until entrance into primary school.

programs at age 3 and 4, followed by kindergarten programs at age 5 and 6 are more likely to score higher on tests administered in primary school. Finally, we estimate the costs associated with the various early education pathways documented in the data to illustrate how the cost-effectiveness of early childhood education can vary considerably based on the sequence of children's enrolment.

This paper is organized as follows. In Section 2, we describe the literature on early grade assessments in developing countries and on early education sequence. Section 3 provides an introduction to early childhood education in rural Indonesia. We describe the data in Section 4. In Section 5 we present descriptive evidence of differences in sequence between children and gaps in test scores. We explain our empirical strategy in Section 6. We present results in Section 7 and provide illustrative estimates of costs associated with various early education pathways in Section 8. Section 9 concludes with a discussion of the findings and their policy implications.

2. Literature review

In developing countries, considerable advances have been made to improve children's access to education, fostered by the Millennium Development Goal to achieve universal primary education. However, children are not adequately learning in schools (Pritchett, 2013). In fact, in far too many school systems children are learning so little that it has been dubbed a learning crisis (World Bank, 2018). An estimated 200 million primary school children in developing countries are struggling to read even basic words (UNICEF, 2012). Others have documented a "twin crisis" in access and learning in schools, whereby high dropout rates are observed in the early grades among children who receive poor quality education (Davidson and Hobbs, 2013). Given that education quality (as measured by cognitive skills) has a strong impact on individual earnings and on economic growth (Hanushek and Woessmann, 2012), the lack of education quality in many education systems around the world has implications for poverty reduction.

Converging research supports the importance of ensuring that children acquire basic skills and competencies during the transitional years into primary school, which is defined as grades 1 to 3 (UNICEF, 2012). One way to measure whether students are in fact learning these foundational skills and competencies is through early grade assessments. Many early grade assessments administered in developing countries do not collect information about children *before* they entered primary school since such information is beyond the scope and purpose of these assessments. However, recent work in economics, education, and neuroscience shows that early childhood investments can have large persistent impacts on subsequent education and on later life outcomes (Cunha et al., 2010; Sylva et al., 2010). For example, results from the OECD's Programme for International Student Assessment (PISA) show that in countries across the world, participation in quality early childhood education is strongly associated with reading performance at age 15, even after controlling for a child's socioeconomic background (OECD, 2012). As a result, linking early grade assessments with children's early education experiences can help researchers and policymakers better understand the factors that influence children's learning during the early years of primary school.

The vast majority of research from developing settings that links early childhood education experiences to children's primary school performance are evaluation studies. Consequently, they compare children who attended preschools with those who never attended, or compare children who attended preschools with improved quality to those who attended non-improved preschools (Engle et al., 2011; Nores and Barnett, 2010, and the references cited therein). Still other studies have examined the difference in school readiness between children with and without access to preschool or school-readiness interventions (Aguilar and Tansini, 2012; Nonoyama-Tarumi and Bredenberg, 2009; Taiwo and Tyolo, 2002).

Such comparisons might provide evidence for investing in

preschools but they often do not adequately capture the reality of many local settings where various types of early education services exist and where children enroll in different types of early education programs at different stages of development. In contexts like these, it is useful to compare different early education service experiences or pathways to understand how they predict children's transition into primary school and subsequent academic achievement. In one of the few studies that examine early childhood education type and children's early learning outcomes in a developing setting, Singh (2014) observes that in the State of Andhra Pradesh in India, enrollment in private preschools is associated with significantly higher test scores at the beginning of primary school relative to those in public preschools. The results highlight the fact that early education experiences can influence the emergence of test score gaps at school-entry.

Existing research typically does not take into account different types of early education pathways in predicting children's performance as they transition into primary school given that such data are often unavailable. Our study leverages a uniquely rich dataset from rural Indonesia that provides detailed histories on children's early education pathways as well as their test scores in the first few years of primary school. Moreover, we extend prior research by examining how the sequence of enrolling in different types of early education programs is associated with early grade learning.

3. Indonesia's early childhood education system

Over the last decade, the government of Indonesia has been implementing policies and programs to prioritize early childhood education and development (ECED). This has resulted in dramatic improvements in ECED enrollment, with the gross enrollment rates increasing from 24.1 percent to 54.4 percent between 2000 and 2013 (World Bank, 2016b). However, access to early education services has historically been unequal, with children from the poorest quintile having significantly lower enrollment rates than those from the wealthiest quintile (Alatas et al., 2013). In response, the government of Indonesia launched an initiative which increased access to early education services in 3000 poor villages in 50 districts throughout the country (Brinkman et al., 2017a, 2015; Jung and Hasan, 2015; Hasan et al., 2013).

Early childhood education in Indonesia consists of a variety of different programs that are overseen by different ministries. Despite the wide range of programs, two types of ECED programs are dominant: playgroups and kindergartens. The Ministry of Education and Culture regulates playgroups (*kelompok bermain, KB*), which are typically for children ages 3–4 and meet three days per week for three hours each day. Playgroups are characterized as play-based learning environments with a combination of both unstructured and structured play activities, typically facilitated by teachers who have nominal formal early childhood education training. Structured play activities generally include songs and dance, and exposure to paints/pencils and paper, and reading sessions where the teacher reads books to the children introducing them to books, letters and numbers. These community playgroups will often have anywhere between 10 and 40 children in some instances. In contrast, kindergartens are regulated by both the Ministry of Education and Culture (for *taman kanak-kanak, TK*) and the Ministry of Religious Affairs (for *raudhotul atfal, RA*). They typically cater to children ages 5–6 and meet five to six days a week for three hours each day. Compared to playgroups, kindergartens emphasize a more academic and structured approach to learning. In addition, the tuition fee for kindergartens is usually higher than playgroups. Although playgroups and kindergartens are intended for specific age groups, these are not always adhered to and families often enroll their children in playgroups and/or kindergartens at various ages before entering primary school at age 7.

Given this landscape, we hypothesize that above and beyond the type of ECED service attended, the sequence of early education may

play a role in children's early grade learning. We define *sequence* as the order in which children of a given age enroll in different ECED programs. Since age requirements are not strictly adhered to, some children may enroll in playgroup then kindergarten before entering primary school, while others may only enroll in kindergarten before primary school. Whether a child enrolls in playgroup at age 3 or 4 or whether a child enrolls at age 5 or 6 matters for the experience they undergo and consequently how prepared they are for primary school.

This paper is particularly timely as the government considers policy options in support of the Sustainable Development Goals. At present, there is no empirical evidence showing what ECED sequence is typical and whether some pathways are associated with better early learning outcomes in Indonesia. On the one hand, it is possible that children will benefit more from continued enrollment in playgroups instead of moving around from playgroup to kindergarten. This hypothesis is partially supported by the fact that research on dosage of early childhood education programs has shown that programs that last 1 to 3 years had average effect sizes of 0.3 standard deviations (S.D.) while programs lasting less than 1 year had average effect sizes of 0.2 S.D. (Nores and Barnett, 2010). Conversely, it is plausible that enrollment in playgroup followed by kindergarten will be associated with better early learning outcomes than enrollment in playgroup only. This alternative hypothesis is supported by recent evidence from the United States showing that children who attended Head Start (a federal preschool program) at age 3 followed by Oklahoma Pre-K (a locally-funded preschool program) at age 4 exhibited stronger early reading skills than children who remained in Head Start at age 4 (Jenkins et al., 2015). The authors posit that children who stayed in Head Start were less likely to receive variation in curricula and activities, while those who switched programs were more likely to benefit from new learning experiences, which are critical for early childhood development (Bronfenbrenner, 1994). Given that in Indonesia playgroups and kindergartens are intended for children of particular ages, this reasoning likely applies to Indonesian children as well.

Thus, the objective of this paper is two-fold. First, it describes the sequence of early education that children in a representative rural sample undergo. Second, it describes how well children in rural Indonesia are acquiring initial skills in reading, mathematics, and general cognition given these experiences. The focus of this paper is to document which early education pathways are prevalent among children in rural Indonesia and what children know in the early years of primary school. Our data do not allow us to make causal claims about the links between early education pathways and children's primary school test scores. Indeed, there are several limitations which we detail below.

4. Limitations

Our analysis controls for a rich set of village-, household-, and child-level characteristics. While these variables influence why students go through different early education pathways, our estimates may be biased if unobserved characteristics are responsible for the differences in early learning outcomes between children that follow different early education pathways. For example, parents particularly motivated by education might send their children to the full sequence of preprimary education at the correct ages, which would lead to positive bias in our estimates. In analyses not shown (but available upon request), we found that the magnitude of the coefficients on early childhood education pathways was larger for a basic model, which does not include any controls for child, household and village characteristics. In other words, including these measurable control variables in our analysis reduced the magnitude of the coefficients on early childhood education pathways. This seems to indicate that unobserved child, household, and village characteristics (which we cannot fully account for in our models) could potentially be upwardly biasing our estimates for early childhood education pathways.

Second, we are not able to causally assess the mechanism through which the combination of playgroup at age 3–4 and kindergarten at age 5–6 may produce higher early learning scores. Further work is needed to investigate early education pathways in other developing countries to better understand the factors that determine the sequence of enrollment more generally. Nonetheless, our results clearly show significant disparities in early learning outcomes by different early education pathways and we find evidence that children from the most socially disadvantaged backgrounds (i.e., low household wealth, low mother's education, lack of access to high quality ECED) were significantly less likely to receive adequate exposure to a complete sequence of preschool services needed to help them succeed in primary school.

Despite these limitations, our study contributes to the literature on early learning in developing countries by showing that even in rural settings various early education pathways exist and that these diverse early education experiences are associated with differences in children's test score performance in the early years of primary school. This has implications as policymakers consider how best to optimize the allocation of scarce public resources on investments in early childhood education.

5. Data and measures

5.1. Data

We use data collected in 2013 as part of an evaluation of a government initiative to increase access to ECED services in rural Indonesia. The sample consists of children, households, and ECED facilities in 310 poor villages in Indonesia. The sample is not meant to be nationally representative of the Indonesian population as a whole; however households in the sample were comparable to the rural subsample of Indonesia's nationally representative SUSENAS household survey (see Hasan et al., 2013). Sampled villages were also compared with a census of villages in Indonesia. The sampled villages for this study appear quite similar to a typical village (Hasan et al., 2013). Our study focuses on the sample of 12,976 children between the ages of 6 and 9 who were enrolled in primary school in 2013 and to whom we administered an early grade assessment covering language, mathematics, and general cognitive skills. Of these children, we have complete detailed retrospective information on their ECED enrollment histories from 2008 for 12,949 children.³ These histories allow us to examine the pathways taken by children starting when they were as young as 1 to 4 years of age.

5.2. Measures

5.2.1. Test scores

Children in the sample were given an early grade assessment that consisted of three sections: language, mathematics, and general cognitive skills. This early grade assessment was designed specifically for this work and is not a standard early grade assessment used in schools. The language and mathematics items on the test were pooled from a battery of questions that align with the national curriculum for lower primary school grades. Thus, these two sections are meant to capture early grade learning in relation to what students are expected to acquire in the first few years of primary school in Indonesia. The general cognitive items on the test are based on the Raven's Colored Progressive Matrices.

Two versions of the test were administered: one for younger children ages 6 and 7, which had a total of 52 items and another one for older children ages 8 and 9, which had a total of 64 items. For both tests, the language section tested children's ability to recognize letters

³ There are 27 children for whom we have missing data on early education pathways. They have been excluded from the analyses of this paper.

Table 1
Summary statistics.

	Mean	S.D.	Min	Max
Test Scores (standardized using scores of 6-year olds)				
Language	0.634	1.002	−1.435	1.951
Math	0.539	0.969	−1.513	1.697
General cognitive skills	0.276	1.071	−1.584	2.878
Sequence of ECED enrolment				
No ECED	0.196	0.397	0	1
Playgroup (3-4) then primary	0.092	0.289	0	1
Kindergarten (5-6) then primary	0.352	0.478	0	1
Playgroup (3-4) then kindergarten (5-6) then primary	0.124	0.329	0	1
Playgroup (5) then kindergarten (6) then primary	0.012	0.109	0	1
Playgroup (5-6) then primary	0.079	0.270	0	1
Other combination	0.145	0.352	0	1
Child characteristics				
Age 6	0.139	0.345	0	1
Age 7	0.291	0.454	0	1
Age 8	0.379	0.485	0	1
Age 9	0.192	0.394	0	1
Grade 1	0.304	0.460	0	1
Grade 2	0.365	0.482	0	1
Grade 3	0.261	0.439	0	1
Girl (1 = Yes)	0.492	0.500	0	1
Stunted (1 = Yes)	0.179	0.383	0	1
Household characteristics				
Household wealth (standardized)	0.065	0.873	−3.573	2.248
Mother's education (years)	7.702	2.647	1	15
Parenting quality (standardized)	0.000	1.000	−5.216	4.198
Village characteristics				
Average ECED quality in village (standardized)	−0.004	0.999	−2.338	2.796
Average monthly ECED fees in village (IDR)	10,779	11,248	0	67,500

Note: All variables were observed in 2013. For sequence of ECED enrollment, retrospective information was collected in 2013 about ECED enrollment as far back as the 2008–2009 academic year. (N = 12,949)

and words, match words to objects, and comprehend short reading passages. The mathematics section tested children's abilities to add, subtract, and order one to two digit numbers. The items based on Raven's Progressive Matrices were intended to measure children's general cognitive skills. 39 items were common across the tests for the two age groups.

We use this subset of 39 test items to construct a common scale using the mean and standard deviation of the 6 year-old group to normalize the test scores (See Appendix A). The advantage of normalizing using the 6 year-olds as a reference group is the ease of interpretation, as we can understand the magnitude of increase in test scores associated with increase in age. The typical child in the sample scored 0.634 standard deviations on language, 0.539 standard deviations on mathematics and 0.276 standard deviations on cognitive skills (see Table 1).

5.2.2. Enrollment histories

ECED enrollment histories were collected by asking children's primary caregivers to retrospectively report the types of ECED service a child had ever been enrolled in (including "no ECED" as a type) and the number of months attended in each type of ECED service during each

academic year since 2008–2009.⁴ Based on this information, we generate a variable for ECED sequence which captures the age of the child at each step in their ECED service sequence. Table 1 presents the mean and standard deviation of each of these variables.

The most common sequence of ECED attendance was to attend kindergarten at age 5–6 before primary school (35.2 percent). 9.2 percent of the sample attended playgroup at age 3–4 before primary school and 7.9 percent attended playgroup at age 5–6 before entering primary school. Among those who attended both playgroup and kindergarten before starting primary school, the vast majority attended playgroup at age 3–4 then kindergarten at age 5–6 (12.4 percent of the sample). Only 1.2 percent of children attended playgroup at age 5 then kindergarten at age 6 before enrolling in primary school.

5.2.3. Child and household characteristics

In addition to primary school test scores and ECED enrollment histories, the survey included a questionnaire administered to the child's primary caregiver, which gathered extensive information on a range of child and household characteristics (See Appendix B for details of variable definition and construction). The majority of children in the sample were either age 7 (29.1 percent) or age 8 (37.9 percent) and as a result, they were found in grade 1 (30.4 percent), grade 2 (36.5 percent) or grade 3 (26.1 percent) at the time of the survey. Approximately half were girls (49.2 percent) and 17.9 percent of the sample were stunted.

At the household level we measured wealth, mother's education, and parenting practices.

In our sample, the mean years of mother's education was slightly over 7 years, suggesting that most mothers had completed primary school (which lasts 6 years).

We also measured parenting practices. These practices are important because children living in an environment with higher-quality parenting are more likely to have higher pre-academic skills, better language skills, more social skills, and fewer behavior problems than children who received lower-quality parenting (NICHD Early Child Care Research Network, 2002).

5.2.4. Village characteristics

Lastly, our data also included characteristic of ECED services averaged at the village level. We assess ECED quality using the Early Childhood Environment Rating Scale Revised (ECERS-R) on a 1–7 scale. (See Appendix B for details). On average, preschools in Indonesia score slightly under 3 (minimal) on the ECERS-R (Brinkman et al., 2017b). Similarly, our data included information on the average monthly fees of ECED services. We used the monthly mandatory fee charged by the services directly to the families, which ranged from zero (free) to 67,500 Indonesian Rupiah, with an average of 10,779 Indonesian Rupiah.⁵ Complete data on ECED service characteristics were only available in the case of 303 villages out of 310. As a result, we have missing observations for ECED characteristics for children in these 7 excluded villages.⁶

6. Differences in enrollment patterns and gaps in test scores

Table 2 documents the various enrollment patterns observed in the data and how they vary between children of different backgrounds. 39.7 percent of the children from the bottom quintile report having attended no ECED at all. This is in contrast to 10.5 percent of children from the top wealth quintile. 7.6 percent of children from the bottom

⁴ This year roughly corresponds to the first time children in our sample would have been eligible to enroll in ECED services.

⁵ During 2013 the exchange rate was approximately 10,000 Rupiah = 1 USD. This suggests that the average amount was 1.1 USD/month and the maximum was 6.75 USD/month.

⁶ These 239 children are therefore dropped from the analysis.

Table 2

Attendance patterns in early childhood education by select child, household and village characteristics.

	No ECED	Playgroup (3-4) then primary	Kindergarten (5-6) then primary	Playgroup (3-4) then kindergarten (5-6) then primary	Playgroup (5) then kindergarten (6) then primary	Playgroup (5-6) then primary	Other combination
	N = 2,539	N = 1,187	N = 4,559	N = 1,600	N = 155	N = 1,027	N = 1,882
Age							
6 (Yes = 1)	0.166	0.105	0.295	0.155	0.006	0.081	0.193
7 (Yes = 1)	0.156	0.103	0.326	0.166	0.011	0.080	0.158
8 (Yes = 1)	0.209	0.094	0.368	0.124	0.016	0.085	0.104
9 (Yes = 1)	0.253	0.061	0.401	0.036	0.011	0.067	0.172
Grade ⁱ							
1 (Yes = 1)	0.171	0.090	0.300	0.156	0.015	0.086	0.183
2 (Yes = 1)	0.179	0.097	0.350	0.152	0.015	0.082	0.125
3 (Yes = 1)	0.227	0.089	0.397	0.079	0.007	0.076	0.126
Gender							
Boy (Yes = 1)	0.213	0.082	0.344	0.117	0.014	0.080	0.151
Girl (Yes = 1)	0.179	0.102	0.361	0.131	0.010	0.079	0.139
Anthropometry							
Stunted (Yes = 1)	0.288	0.109	0.365	0.107	0.015	0.116	0.001
Not stunted (Yes = 1)	0.176	0.088	0.349	0.127	0.011	0.071	0.177
Wealth							
Bottom quintile (Yes = 1)	0.397	0.122	0.283	0.076	0.009	0.111	0.002
Top quintile (Yes = 1)	0.105	0.082	0.504	0.227	0.015	0.061	0.006
Mother's education ⁱⁱ							
Below mean (Yes = 1)	0.241	0.089	0.275	0.075	0.010	0.085	0.225
Above mean (Yes = 1)	0.115	0.096	0.489	0.210	0.016	0.070	0.003
Parenting quality							
Bottom quintile (Yes = 1)	0.276	0.096	0.383	0.121	0.017	0.108	0.001
Top quintile (Yes = 1)	0.194	0.112	0.433	0.154	0.013	0.094	0
ECED quality in village							
Bottom tercile (Yes = 1)	0.205	0.099	0.367	0.094	0.009	0.079	0.148
Top tercile (Yes = 1)	0.161	0.080	0.355	0.179	0.019	0.081	0.125

Note: ⁱ Only grades 1, 2 and 3 are reported since the vast majority of children were enrolled in these three grades as shown in Table 1. ⁱⁱ Mean years of mother's education is 7.7 years for this sample (see Table 1).

quintile report having attended playgroup at age 3–4 and then kindergarten at age 5–6 before primary school. By comparison 22.7 percent of the top quintile follow this pattern. Attending kindergarten at age 5–6 before primary school is much more common among the top wealth quintile – 50.4 percent of this quintile does so – while only 28.3 percent of the bottom quintile does so.

As Table 3 documents, considerable disparities in test scores already exist in the early years of primary school between children who are socially disadvantaged compared to those who are less so – even among children living in poor villages in Indonesia. Children whose mothers had less than the mean years of education (7.7 years) scored about 0.4 standard deviations less (in both language and cognitive skills) than those whose mothers had more than the mean years of education. The test score gap is particularly striking between children in the bottom and top quintiles of the wealth distribution. Children in the top 20 percent of the wealth distribution scored 0.63 standard deviations higher than those in the bottom 20 percent in cognitive skills and 0.70 standard deviations higher in language.

In order to interpret the magnitude of these test score gaps, we looked at the incremental increase in test score from one year of primary school in language and math. We focused on these two tests because they align with the curriculum in primary school and, as such, we would expect improvements in test scores as children progress through school. As shown in Table 3, the test score gap between grade one and two was 0.60 standard deviations for language and 0.50 standard deviations for math. Between grade two and three, the test score increases were 0.34 and 0.25 standard deviations for language and math,

respectively. Averaged together, this suggests that one year of primary school is associated with a 0.47 standard deviation increase in language and a 0.36 standard deviation increase in math.

Based on this assumption, the gap in test scores between those in the top wealth quintile and bottom wealth quintile is equivalent to 1.5 and 1.9 years of primary schooling. This suggests that even among poor, rural families in Indonesia, household wealth is strongly associated with children's early learning outcomes. Given that we observe these substantial disparities in test scores within the first few years of primary school, we seek to understand how children's early education pathways may play a role in predicting these divergent outcomes.

7. Empirical strategy

We begin by estimating who selects into different ECED service pathways using a multinomial logistic regression. Playgroup (age 3–4) then kindergarten (age 5–6) then primary is chosen to be the base outcome ($h = 1$) for our analysis when the multinomial logit parameters are estimated for the other six pathways ($h = 2-7$) as follows: no ECED; playgroup (age 3–4) then primary; kindergarten (age 5–6) then primary; playgroup (age 5) then kindergarten (age 6) then primary; playgroup (age 5–6) then primary; and other combination. By setting $\beta_1 = 0$ for the base group, we estimate the following multinomial equations for a particular pathway h :

$$p_{ih} = \Pr[Y_i = h] = \frac{\exp(x_i'\beta_h)}{\sum_{l=1}^7 \exp(x_i'\beta_l)} \text{ where } h = 1, 2, \dots, 7 \quad (1)$$

Table 3

Test scores by select child, household, and village characteristics.

		Language	Math	Cognitive	N
Age					
6	Mean	0.000	0.000	0.000	1,794
	95% CI	[-0.046 - 0.046]	[-0.046 - 0.046]	[-0.046 - 0.046]	
7	Mean	0.385	0.400	0.308	3,762
	95% CI	[0.352 - 0.418]	[0.369 - 0.432]	[0.273 - 0.342]	
8	Mean	0.849	0.681	0.275	4,910
	95% CI	[0.824 - 0.874]	[0.655 - 0.706]	[0.246 - 0.305]	
9	Mean	1.042	0.856	0.431	2,483
	95% CI	[1.009 - 1.075]	[0.823 - 0.889]	[0.387 - 0.474]	
Grade					
1	Mean	0.0892	0.113	0.056	3,934
	95% CI	[0.0576 - 0.121]	[0.0809 - 0.144]	[0.0246 - 0.0880]	
2	Mean	0.685	0.584	0.272	4,732
	95% CI	[0.659 - 0.711]	[0.558 - 0.611]	[0.241 - 0.303]	
3	Mean	1.026	0.835	0.440	3,385
	95% CI	[0.999 - 1.054]	[0.807 - 0.862]	[0.404 - 0.476]	
Gender					
Boys	Mean	0.552	0.458	0.276	6,581
	95% CI	[0.528 - 0.577]	[0.435 - 0.482]	[0.249 - 0.302]	
Girls	Mean	0.718	0.622	0.277	6,368
	95% CI	[0.694 - 0.742]	[0.598 - 0.645]	[0.251 - 0.302]	
Anthropometry					
Stunted	Mean	0.507	0.388	0.159	2,319
	95% CI	[0.465 - 0.549]	[0.347 - 0.429]	[0.116 - 0.202]	
Not Stunted	Mean	0.661	0.571	0.302	10,630
	95% CI	[0.643 - 0.680]	[0.553 - 0.590]	[0.281 - 0.322]	
Wealth					
Bottom quintile	Mean	0.312	0.199	0.004	2,591
	95% CI	[0.273 - 0.351]	[0.160 - 0.238]	[-0.0343 - 0.0431]	
Top quintile	Mean	1.009	0.886	0.633	2,577
	95% CI	[0.975 - 1.043]	[0.854 - 0.917]	[0.592 - 0.675]	
Mother's education ⁱ					
Below mean	Mean	0.489	0.396	0.143	8,306
	95% CI	[0.467 - 0.511]	[0.374 - 0.417]	[0.120 - 0.165]	
Above mean	Mean	0.893	0.794	0.515	4,643
	95% CI	[0.866 - 0.919]	[0.769 - 0.820]	[0.484 - 0.546]	
Parenting quality					
Bottom quintile	Mean	0.575	0.479	0.212	2,752
	95% CI	[0.537 - 0.612]	[0.443 - 0.515]	[0.173 - 0.251]	
Top quintile	Mean	0.767	0.681	0.354	2,325
	95% CI	[0.728 - 0.807]	[0.643 - 0.719]	[0.311 - 0.398]	
ECED quality in village					
Bottom tercile	Mean	0.527	0.432	0.157	4,051
	95% CI	[0.497 - 0.558]	[0.402 - 0.461]	[0.125 - 0.189]	
Top tercile	Mean	0.717	0.602	0.377	4,351
	95% CI	[0.687 - 0.747]	[0.572 - 0.631]	[0.345 - 0.410]	

Note: ⁱ Mean years of mother's education is 7.7 years for this sample (see Table 1).

where x_i is a vector of an intercept and a vector of child-level characteristics (age, grade, gender, and stunting), household-level characteristics (household wealth, mother's education, and parenting quality), village-level characteristics (ECED quality and fees), and district fixed effects which were included as a dummy variable for each district excluding one as the base. Thus, the coefficients β_2 to β_7 measure the change relative to the base outcome. Standard errors were clustered at the village level.

Table 4 reports the estimates of exponential coefficients from this regression. In each of these analyses, we examined which child and household characteristics strongly predict different early education pathways. We were also interested in how village ECED quality and fees predict different early education pathways since families may make decisions about the sequence of ECED participation based in part on the quality and cost of ECED services in their village.⁷

Then, using a multivariate ordinary least squares regression for each primary school assessment, we estimated the association between different early education pathways and children's test scores as follows:

$$Y_{ij} = \alpha + \beta_1 \text{Sequence}_{ij} + \beta_2 \text{Child}_{ij} + \beta_3 \text{Household}_{ij} + \beta_4 \text{Village}_{ij} + \beta_5 \text{District}_{ij} + \varepsilon_{ij} \quad (1)$$

where Y_{ij} was the test score (language, math or cognitive skills) of child i in primary school living in village j and Sequence_{ij} was a categorical variable indicating the child's ECED sequence. We also included the entire set of covariates presented in Table 1. Standard errors were clustered at the village level in the estimation. The results of this estimation are reported in Table 5 for each test: language, mathematics and cognitive skills.

(footnote continued)

Eq. (1) using duration of ECED as the outcome. Definitions and descriptive statistics are available in the Appendix.

⁷ In Appendix 3, we also provide supplemental analyses of how families select into different duration of ECED services. We estimate the multinomial logit in

Table 4
Multinomial logistic regression of ECED sequence.

	Sequence (base: Playgroup (3-4) then kindergarten (5-6) then primary)					
	No ECED	Playgroup (3-4) then primary	Kindergarten (5-6) then primary	Playgroup (5) kindergarten (6) then primary	Playgroup (5-6) then primary	Other combination
Child characteristics						
Age	1.724*** (0.0752)	1.257*** (0.0606)	1.639*** (0.0624)	1.647*** (0.137)	1.380*** (0.0667)	1.353*** (0.0616)
Girl	0.722*** (0.0579)	1.074 (0.0892)	0.932 (0.0579)	0.684** (0.101)	0.866* (0.0711)	0.787*** (0.0614)
Stunted	1.286** (0.144)	1.229* (0.151)	1.128 (0.106)	1.411* (0.268)	1.496*** (0.179)	0.00238*** (0.00239)
Household characteristics						
Wealth Z-score	0.398*** (0.0374)	0.576*** (0.0537)	0.850** (0.0594)	0.841 (0.109)	0.580*** (0.0547)	0.607*** (0.0506)
Mother's education (years)	0.780*** (0.0177)	0.895*** (0.0206)	0.942*** (0.0146)	0.923** (0.0305)	0.829*** (0.0197)	0.790*** (0.0132)
Parenting practices	0.892** (0.0430)	1.041 (0.0539)	1.004 (0.0369)	0.890 (0.0835)	0.923 (0.0515)	0.924** (0.0358)
Village characteristics						
ECED quality (base: Bottom tercile)						
Middle tercile	0.965 (0.287)	0.965 (0.275)	0.853 (0.176)	0.916 (0.287)	0.935 (0.281)	0.998 (0.256)
Top tercile	0.361*** (0.103)	0.389*** (0.107)	0.467*** (0.0901)	1.061 (0.295)	0.490** (0.149)	0.443*** (0.104)
ECED fees (base: No fees)						
≤ 10,000 IDR	0.233*** (0.0831)	0.260*** (0.0986)	0.253*** (0.0648)	1.085 (0.564)	0.303*** (0.117)	0.256*** (0.0968)
> 10,000 IDR	0.202*** (0.0747)	0.173*** (0.0677)	0.282*** (0.0709)	1.612 (0.825)	0.229*** (0.0911)	0.290*** (0.110)
Constant	1.078 (0.568)	1.976 (1.066)	0.592 (0.250)	0.00399*** (0.00361)	1.249 (0.717)	5.215*** (2.960)
Observations	12,690					

Note: Exponentiated coefficients. Standard errors clustered at the village level in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In these analyses, we were interested in testing multiple pairwise comparisons for each type of ECED sequence. We tried to mitigate why students went through different early education pathways using a rich set of information on child, household, and village characteristics. As noted at the outset, it is not possible to control for unobserved child and household characteristics that may affect the early learning outcomes between children who went through different early education pathways. Thus, we caution against interpreting our estimates as causal – these are merely associations.⁸

8. Results

First, we examine the extent to which children (and their parents) self-select into various ECED pathways using the multinomial logit of Eq. (1). The results of the multinomial logit regression with exponentiated coefficients (relative risk ratios) are shown in Table 4 below. Our preferred outcome is the base scenario, which is enrollment in playgroup at age 3–4 followed by kindergarten at age 5–6. Thus, we interpret the exponentiated coefficients of each sequence relative to the coefficient for this base category. Relative risk ratios greater than one indicate that as the value of the variable increases, the risk of the outcome falling into that category increases relative to the risk of the outcome being in the base category. Conversely, if the relative-risk ratio is smaller than one, the outcome is more likely to be in the base category.

⁸ In Appendix 4, we also provide supplemental analyses of the association between different early education duration and children's test scores. We estimate the OLS regression in equation (2) using duration of ECED as the main predictor.

Among the child-level variables, we found that older children in the sample were consistently more likely to have never enrolled in ECED. Conversely, younger children were more likely to enroll in playgroup at age 3–4 then kindergarten at age 5–6. This was not surprising given that access to early education in villages was expanded by the Indonesian government from 2009, which meant that younger children were more likely to have had the opportunity to enroll in playgroups than older children. Compared to children who are not stunted, those who are stunted are 1.2 to 1.5 times more likely to enroll only in playgroups and 1.4 times more likely to enroll in playgroup at age 5 followed by kindergarten at age 6 than to enroll in the preferred base outcome.

Among the household-level variables, we found that household wealth and mother's education were both significant predictors of ECED sequence. As household wealth increased, children were more likely to be enrolled in playgroup at age 3–4 then kindergarten at age 5–6 compared to other possible sequences. More importantly, mother's education was the only significant household-level variable that predicted enrolment in playgroup at age 5 followed by kindergarten at age 6. A relative risk ratio of 0.9 means that children whose mothers have higher levels of education are more likely to enroll in playgroup and kindergarten at developmentally appropriate ages (the base category). Thus, mother's education is a key predictor in ensuring that children enroll in the full sequence of ECED at the right ages.

For village-level characteristics, we examined ECED quality and fees. We hypothesized earlier that families make decisions about early education pathways based in part on the quality of the ECED services in their village. We found support for this hypothesis. For children in villages with ECED quality in the top tercile, the relative risk ratios were statistically significant and consistently smaller than one, ranging from 0.36 to 0.49. This means that if a child were to move from a

Table 5
Association of ECED sequence and test scores in primary school.

	Sequence		
	Language (1)	Maths (2)	Cognitive Skills (3)
Sequence (Base: No ECED [I])			
Playgroup (3-4) then primary [II]	0.0854*** (0.0318)	0.116*** (0.0312)	0.0650* (0.0356)
Kindergarten (5-6) then primary [III]	0.238*** (0.0228)	0.221*** (0.023)	0.133*** (0.0269)
Playgroup (3-4) then kindergarten (5-6) then primary [IV]	0.418*** (0.0289)	0.427*** (0.0292)	0.205*** (0.0358)
Other combination [V]	0.440** (0.174)	0.304 (0.196)	0.117 (0.251)
Playgroup (5-6) then primary [VI]	0.0225 (0.0333)	0.0529 (0.0327)	−0.0131 (0.0377)
Playgroup (5) then kindergarten (6) then primary [VII]	0.320*** (0.0716)	0.308*** (0.0676)	0.141* (0.0844)
Constant	−0.559*** (0.0379)	−0.510*** (0.0381)	−0.352*** (0.0445)
Observations	12,690	12,690	12,690
R-squared	0.281	0.233	0.108
Pairwise contrasts			
[II] - [I]	0.0854***	0.116***	0.0650*
[VI] - [II]	−0.0629*	−0.0629*	−0.0781*
[III] - [II]	0.153***	0.105***	0.0680**
[IV] - [III]	0.180***	0.207***	0.0715**
[VII] - [IV]	−0.0983	−0.119*	−0.0634

Note: Robust standard errors clustered at the village level in parentheses. All regressions include child characteristics (age, grade, gender, and stunting), household characteristics (household wealth, mother's education, parenting practices), village characteristics (average ECED quality and fees).

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

village with low ECED quality to high ECED quality, we would expect the child to be more likely to enroll in the full sequence of early education – playgroup at age 3–4 then kindergarten at age 5–6 – rather than in playgroups only or kindergartens only. Fig. 1 below illustrates these results, showing how the predicted probability of enrolling in various early education sequences and timing varies with quality and household-level predictors. The plots show that as household wealth and mother's education increases, the probability of enrolling in the full sequence of early childhood education increases, with a steeper increase for children living in villages with higher ECED quality.

For ECED fees the relative risk ratio ranged from 0.17 to 0.30, which means that children living in villages that charge fees were less likely to be enrolled in only playgroup or kindergarten, and conversely, more likely to be enrolled in playgroup followed by kindergarten. For ease of interpretation, the result in Table 4 for the ECED fee variable is plotted in Fig. 2 below. The predicted probability of enrolling in the full sequence of playgroup and kindergarten increases more steeply for children living in villages that charge some fees (both the “less than 10,000 IDR” and “more than 10,000 IDR” categories) compared to villages that charge no fees. This is an unexpected result since our estimation controlled for household wealth as well as quality of ECED services. In other words, if two children had the exact same household wealth and had access to ECED services of the same quality, the child living in a village that charged early education fees would be more likely to enroll in the full sequence of ECED at developmentally appropriate ages (i.e., playgroup at age 3–4 then kindergarten at age 5–6) than the child living in a village that did not charge any fees. A possible explanation for this result is that villages that charge higher fees may be able to do so because they have stronger community-wide support for early childhood education, which in turn also promotes families to enroll their children in the full sequence of early education at the appropriate ages.

Thus, our multinomial logistic regressions suggest that there is considerable self-selection into different early education pathways. First, compared to older children in the sample, younger children were more likely to enroll in the full sequence of early education at developmentally appropriate ages. Second, household wealth was a significant predictor of early education sequence, even after controlling for variables at the child-level (age, gender and stunting), household-level (mother's education and parenting practices) and village-level (ECED quality and amount of fees). Third, children whose mothers had higher levels of education were significantly more likely to enroll in playgroups and kindergarten at the intended ages rather than delay their entry into playgroup and kindergarten. Finally, children living in villages with higher quality ECED services were significantly more likely to enroll in the full sequence of playgroup and kindergarten at the intended ages than children living in villages with lower quality ECED services.

Next we present the results of the relationship between early education pathways and test scores. These results are presented in Table 5. In this table, the dependent variable is the language test score in column 1, the mathematics test score in column 2, and the cognitive skills test score in column 3. The pairwise comparisons between children who enrolled in different early education pathways are shown at the bottom of Table 5.

In Table 5, we found evidence that the sequence of ECED was a significant predictor of primary school test scores. Children who enrolled in playgroup at age 3–4 then kindergarten at age 5–6 before entering primary school performed significantly higher in language and math compared to those who enrolled only in kindergarten at age 5–6 – even after controlling for key child-, household- and village-level covariates. The magnitude of this difference was 0.2 standard deviations in both language and math. Similarly, children who enrolled in playgroup at age 3–4 then kindergarten at age 5–6 before entering primary school performed 0.3 standard deviations higher in language and math compared to those who enrolled only in playgroup at age 3–4 (obtained from [IV] – [II] in columns 1 and 2). This suggests that enrolling in the full sequence of early education services at developmentally appropriate ages is a significant predictor of children's subsequent learning outcomes. We find somewhat smaller results for general cognitive skills, with a 0.1 standard deviations difference between those who enrolled in playgroup at age 3–4 then kindergarten at age 5–6 and those who only enrolled in kindergarten or only enrolled in playgroup.

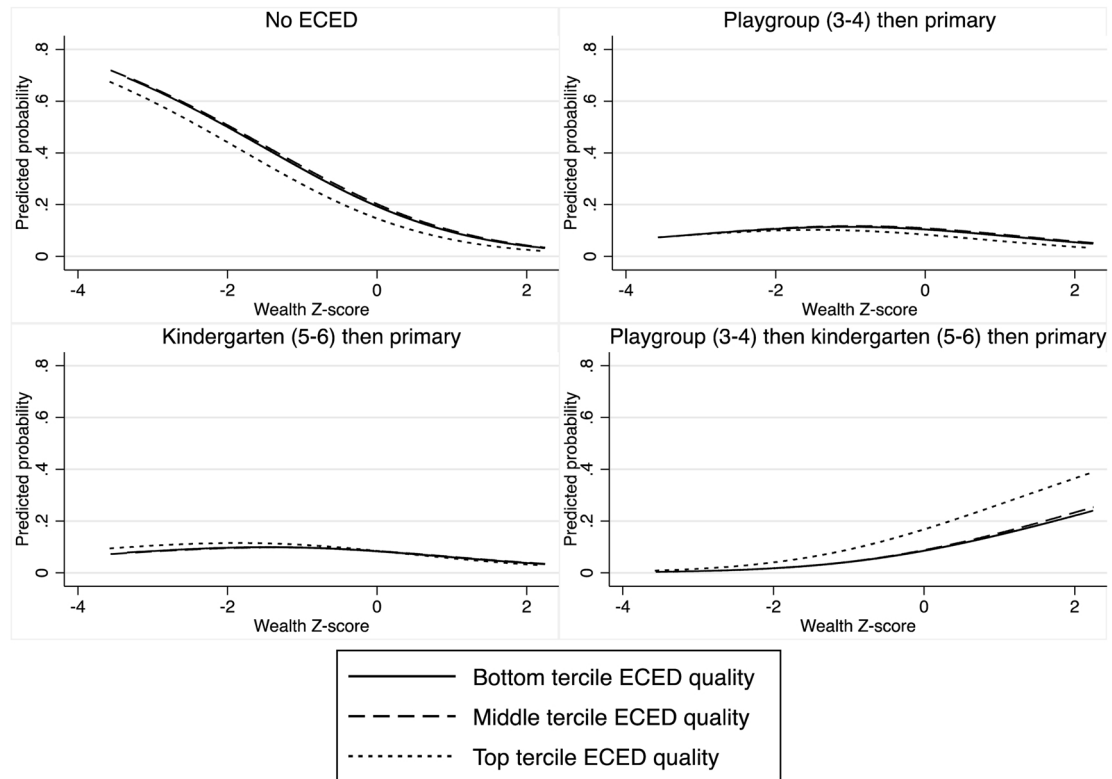
Overall, our analysis of early education pathways, as it relates to early grade learning, shows that on average, children who enrolled in playgroup followed by kindergarten scored significantly higher in language and math tests in the early years of primary school compared to their peers who enrolled only in playgroup or only in kindergarten. Children who enrolled in playgroup at age 3–4 followed by kindergarten at age 5–6 performed significantly higher in language and math tests in primary school than their peers who enrolled in other early education pathways.

9. Understanding the cost-effectiveness of various early education pathways

The Indonesian government continues to weigh alternatives through which it can invest smartly in early childhood education to ensure that all young children enter primary school ready to learn.

In this section, we present illustrative estimates of the cost-effectiveness of various early education pathways. An important caveat to these cost-effectiveness figures is that they are not causal estimates. The estimates suffer from omitted variable bias since we are not able to account for all factors that may possibly affect both a child's early childhood education pathway and his/her subsequent primary school test scores. In our case, the direction of the bias is upwards given that children from more advantaged backgrounds (as measured by household wealth, mother's education, and the quality of available services in

A. Household wealth



B. Mother's education

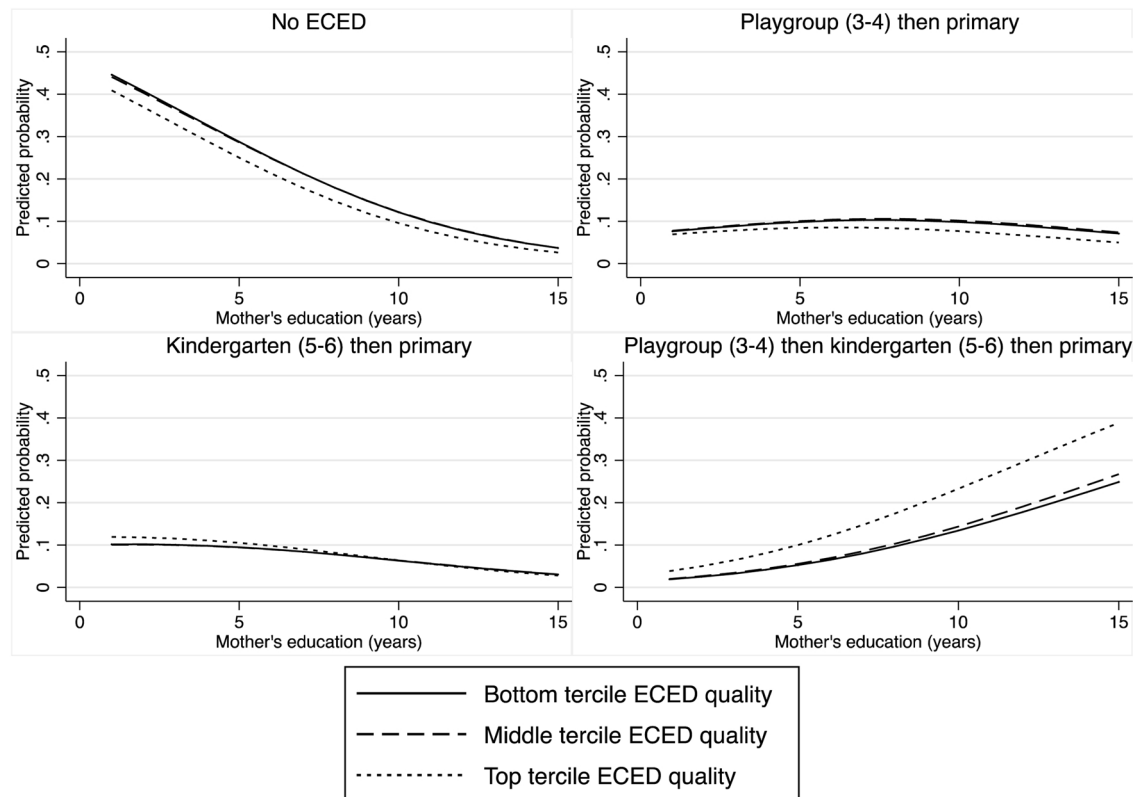


Fig. 1. Predicted probability of ECED pathway by quality and key household characteristics.

Note: Graphical representation of multinomial logistic regression output in Table 4. Only the four most common ECED sequence categories are shown (based on proportion of children in each sequence category in Table 1). All figures control for child characteristics (age, gender, and stunting), parenting practices, and village characteristics (ECED quality and fees). In addition, Panel A controls for mother's education and Panel B controls for wealth z-score.

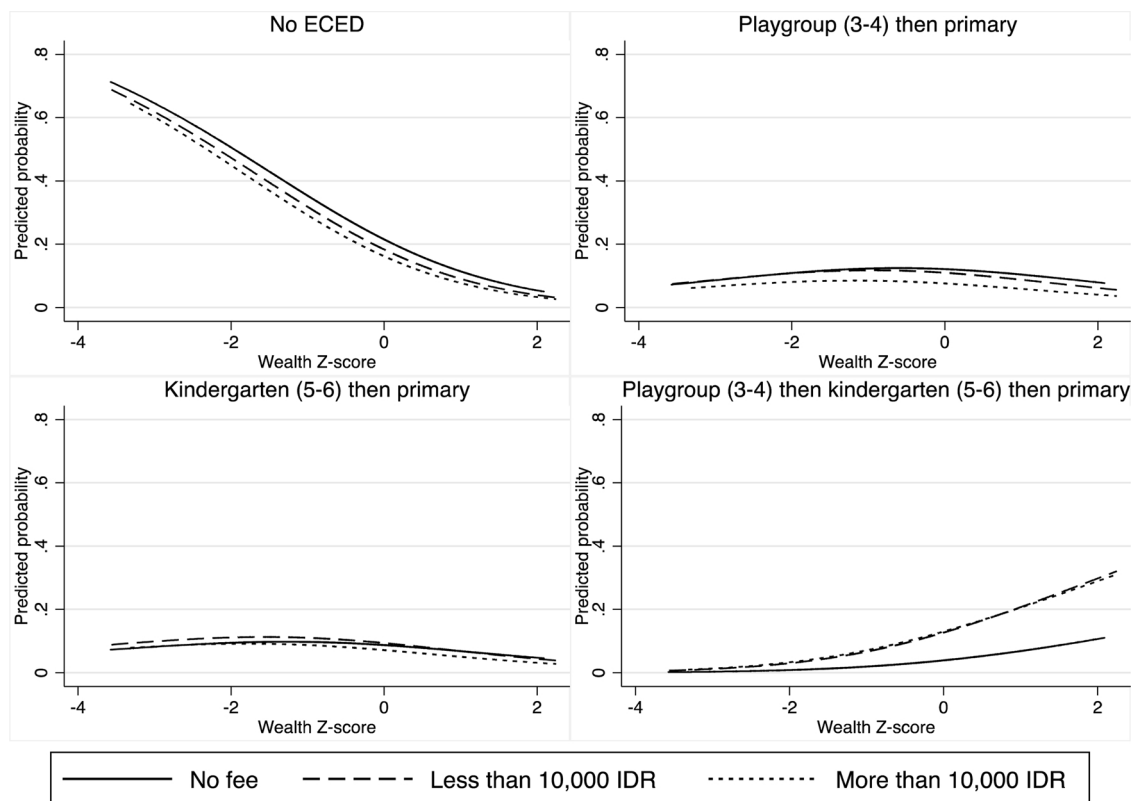


Fig. 2. Predicted probability of ECED pathway by fees and household wealth.

Note: Graphical representation of multinomial logistic regression output in Table 4. Only the four most common ECED sequence categories are shown (based on proportion of children in each sequence category in Table 1). All figures control for child characteristics (age, gender, and stunting), household characteristics (wealth, mother's education, and parenting practices), and village characteristics (ECED quality and fees).

their village) are more likely to have enrolled in the full sequence of early childhood education and more likely to obtain higher test scores in primary school. Thus, the cost-effectiveness figures in this paper should be interpreted as upper-bound estimates of the “true” causal cost-effectiveness.

Prior research in education has demonstrated that failure to account for omitted variable bias can yield misleading results. For example, cross-sectional studies comparing private and public primary schools in India document a substantial private school premium in math and native language test scores, ranging from 0.25 S.D. (Singh, 2015) to 0.65 S.D. (Muralidharan and Sundararaman, 2015). However, once studies account for selection into schools using sub-district fixed effects, lagged test scores, and extensive controls (Singh, 2015) or random assignment (Muralidharan and Sundararaman, 2015), the private school premium disappears. To examine the sensitivity of our cost-effectiveness estimates to omitted variable bias, we perform the bounding approach proposed by Oster (2017) based on the framework in Altonji et al. (2005) (See Appendix E for details).

Although the results presented are not causal estimates of the effects of ECED pathways on primary school test scores, we believe that estimates can help to inform public resource allocation decisions for early childhood education in Indonesia. To underscore that these are illustrative calculations we only provide comparisons for two scenarios – some ECED and the “ideal” or preferred full sequence of playgroup at age 3–4 followed by kindergarten at age 5–6 (no early childhood education was the reference category in all the analyses).

Costs were calculated using the ingredients method (Levin and McEwan, 2001), which included personnel, facilities, equipment and materials, fees charged to families, and other operational costs of playgroups and kindergartens. Effectiveness is measured using the language and math assessments. We used the language and math

assessments for our effectiveness measure as these two tests were aligned with what children were expected to know in the early years of primary school. For meaningful interpretation of our results, we converted from standard deviation units to equivalent years of education using the average test score increase from one year of primary school as estimated in Table 3. We did this separately for language and maths. Specifically, we divided our estimates by 0.5 standard deviations in language and 0.4 standard deviations in math to calculate the equivalent years of education children gain from attending early childhood education.⁹

The cost of each early education pathway was drawn from the Indonesia ECED Project evaluation data (World Bank, 2014) and the 2012 *Nomor Unik Pendidik Dan Tenaga Kependidikan* (NUPTK), which is the national teacher database (Ministry of Education and Culture, 2012a). To estimate annual costs per child, we assumed that the average center size is 31 children per kindergarten and 21 children per playgroup (Ministry of Education and Culture, 2012b), and that the average student to teacher ratio was 15:1 in kindergarten and 11:1 in playgroups (as per the Indonesian minimum service standards). Based on these assumptions, we estimated total annual costs to be approximately 151 USD per child in playgroups and 256 USD per child in kindergartens.

We divided the effectiveness of each of the selected early education pathways by its cost to calculate illustrative effectiveness-cost ratios. This means that the more effective the early education pathway, the

⁹ We estimated the effectiveness of the ECED sequence variable by controlling for child characteristics (age, grade, gender, and stunting), household characteristics (household wealth, mother's education, parenting practices), and village characteristics (average ECED quality and fees) (see Appendix Table E1 for details).

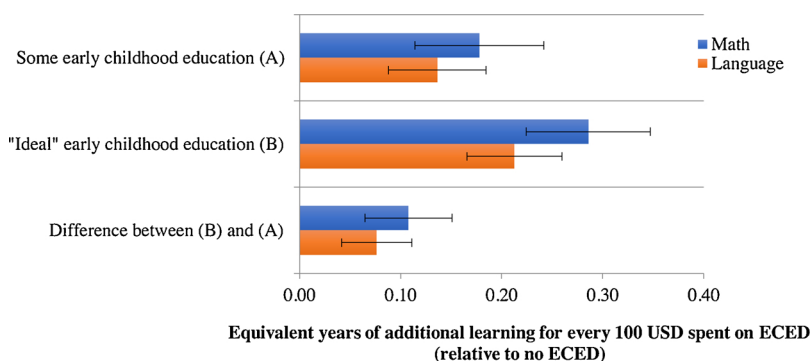


Fig. 3. Illustrative cost-effectiveness of selected early education pathways.

Note: The figure shows the amount of additional learning (measured in years) for every 100 USD spent on early childhood education. The category “Some early childhood education” refers to children enrolled in only playgroup, only kindergarten, or a combination of playgroup and kindergarten but at later ages than developmentally appropriate. The category “Ideal early childhood education” refers to children enrolled in playgroup at age 3–4 then kindergarten at ages 5–6 then primary. The difference between (B) and (A) is statistically significant at the $p < 0.01$ level. Effectiveness is measured using math and language test scores of children measured at ages 6 through 9. Cost is assumed to be a total of 150.97 USD per child for one year of playgroup and 256.25 USD per child for one year of kindergarten. Test score improvements are based on the regressions in Appendix Table E1 Column 2. Error bars show 95% confidence intervals.

larger the effectiveness-cost ratio. The results are presented in Fig. 3.

Our back-of-the-envelope calculation suggests that enrollment in the full sequence of playgroup and kindergarten at developmentally-appropriate ages is associated with an additional 0.21 years of learning in language and 0.29 years of learning in math for every 100 USD invested in early childhood education. In contrast, enrollment in some ECED – collapsing together children who attended only playgroup, only kindergarten, or a combination of playgroup and kindergarten at later ages – is only associated with an additional 0.14 years of learning in language and 0.18 years of learning in math for every 100 USD invested in early education. Furthermore, the difference in additional learning for a full sequence of ECED at the appropriate ages and for some ECED is practically and statistically significant at the $p < 0.01$ level. Note that the results presented in Fig. 3 are upper-bound estimates of the “true” cost-effectiveness. Appendix E provides a sensitivity analysis of these effectiveness estimates to omitted variable bias using the method proposed by Oster (2017). As expected, the magnitude of our effectiveness estimates decline when we take into account omitted variable bias but even our lower-bound estimates yield positive and significant coefficients at the $p < 0.01$ level. Thus, our results suggest that unobservables are unlikely to change our core finding that enrolling in ECED pathways at developmentally-appropriate ages is associated with higher primary school test scores.

Calculations such as these can help in understanding which combination of playgroup and kindergarten might be most cost-effective for a given population. Our estimates, while only illustrative, would indicate that focusing on providing access to both playgroups and kindergartens to young children at the appropriate ages would be better a public investment in early childhood education than in either playgroup or kindergarten on their own.

10. Discussion

As developing countries increase investments in early childhood education, one of the challenges faced by policymakers is deciding what to fund given the wide range of programs that exist in local settings. Our study examined this issue in the context of rural Indonesia, by first analyzing the extent to which families select into different early education pathways. Then we described early learning outcomes and explored how they are associated with these early education pathways. Finally, we provided illustrative estimates of the cost-effectiveness of various pathways to shed light on how decision-making about investments in early childhood education needs to take into account the sequence of such programs.

The results of our study show that there is significant self-selection into different early education pathways. The predicted probability of

enrolling in playgroup at age 3–4 and kindergarten at age 5–6 significantly increases with household wealth, mother’s education, and availability of high quality ECED services. Such disparities in early education experiences by household characteristics raises the question of how the government of Indonesia can better allocate scarce resources to ensure that children from the most socially disadvantaged backgrounds have an equal chance at success in primary school. Illustrative cost-effectiveness analyses from our study suggest that providing a combination of playgroup at age 3 and/or 4 followed by kindergarten at age 5 and/or 6 may potentially be a cost-effective way forward.

Our results clearly show significant disparities in early learning outcomes by different early education pathways. We find evidence that children from the most socially disadvantaged backgrounds (i.e., low household wealth, low mother’s education, lack of access to high quality ECED) were significantly less likely to receive adequate exposure to a complete sequence of preschool services needed to help them succeed in primary school. Yet it is precisely these very children for whom these services are likely to be most effective. This suggests that the current ECED policy landscape is not leveling the playing field to ensure that children from the most socially disadvantaged backgrounds have an equal chance at performing well once they enter primary school. To address this, access to both playgroups and kindergartens needs to be expanded in poor villages in Indonesia. More broadly, the results of this study highlight the importance of carefully considering how the sequence of different ECED programs support children’s development in the early years when policymakers are faced with the challenge of deciding what type(s) of ECED programs to invest in.

Our findings show that there are substantial disparities in early learning outcomes by early education sequence. Children who enroll in playgroup at age 3–4 followed by kindergarten at age 5–6 scored significantly higher in language and mathematics in the beginning of primary school compared to peers who took a different pathway. This is consistent with a study from the United States which found that children who transition from one preschool program to another outperform children who remain in the same preschool program (Jenkins et al., 2015).

In the Indonesian context, the added marginal effect of enrolling in playgroup then kindergarten is likely due to the different curricula used in playgroups and kindergartens. Children in playgroups predominantly learn through play whereas kindergartens focus on more academic activities to prepare children for primary school. Neuroscience research has shown that secure attachments and stimulation are significant aspects of brain development in the early years and play-based learning helps children develop their fine and gross motor skills, develop language and socialization skills, and become creative problem-solvers.

Play not only enhances children’s learning readiness but also can more generally help them adjust to school settings (Zigler et al., 2004). Child development research has also shown that children’s intellectual development is best supported when children receive increasingly complex, differentiated learning experiences (Bronfenbrenner, 1994; Engel et al., 2013).

However, playgroups in Indonesia were not designed to provide multiple years of unique, developmentally appropriate learning. They also meet less frequently than other types of services. As a result, children who subsequently enroll in kindergarten are more likely to avoid redundancy in their learning experiences by having exposure to different, more academically-focused curricula. We caution against interpreting these results as support for solely academically-focused early education given that child development research shows that children who are exposed to play-based learning in the early years are significantly more likely to have positive socio-emotional development than children who are only exposed to academic preschools (Elkind, 2008). Instead, we interpret the results as evidence that early childhood education must support children’s learning at various stages of development and in the context of Indonesia, this is most strongly supported

when children enroll in a play-based early education setting (playgroup) followed by a more structured and increasingly academic-based environment (kindergarten) prior to primary school. Given that current policy debates are centered around whether and what type of preprimary education to make compulsory, these findings are timely.

Funding

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Appendix A. Standardizing Test Scores

See Fig. A1 and A2.

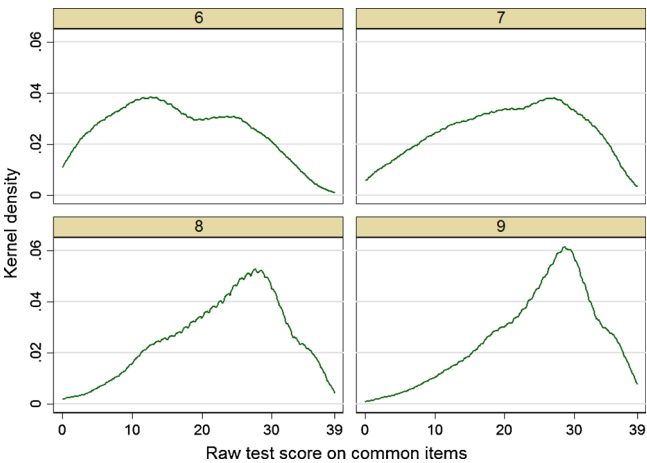


Fig. A1. Kernel density of 39-common-item test by age.

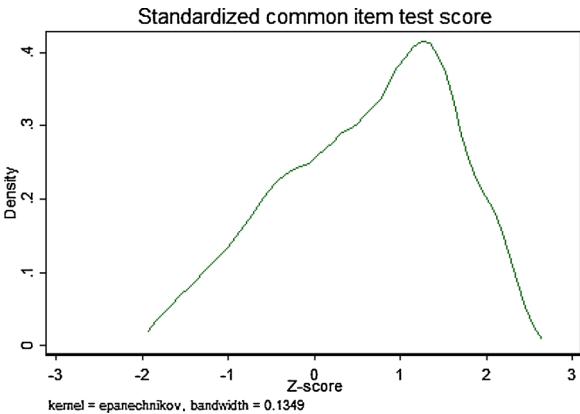


Fig. A2. Kernel density of 39-common-item test (standardized test score).

Appendix B. Variables and their construction

See [Table B1](#).

Table B1

A closer look at key variables and their construction.

Measure	Definition	Notes
Stunting	This paper defines stunting as both "moderately stunted" and "severely stunted" (any child with a height-for-age Z score below -2).	To estimate the proportion of children who were stunted, we use the World Health Organization definition of height-for-age Z-score 2 standard deviations below the median (De Onis, 2006). Stunting statistics are typically reported for children under the age of 5. In this sample, stunting was measured in 2013 when the children were between ages 6-9 (with nearly 70% of the children being age 7 or 8). According to national figures 37% of Indonesian children under the age of five are stunted. When the children in our sample were age 5, approximately 36.1% of them were stunted.
Parenting practices	The primary caregiver of each child was asked a range of questions about their parenting practices that reflect different levels of warmth, consistency, and hostility.	These practices were measured using 24 items describing parent-child relationships adapted from the Longitudinal Study of Australian Children (LSAC) (Zubrick et al., 2008). Mothers were asked how often they used each of a number of different parenting practices. Scores were then created for each dimension separately, and a total positive parenting practices score created by adding together scores for each of the three parenting dimensions (with the negative items reversed). The higher the score, the more likely it is that parents have high levels of warmth and consistency, and low levels of hostility toward their children. The resulting scores for parenting practices were standardized to have a mean of 0 and a standard deviation of 1.
Household wealth	Households were asked if they owned any of the following: radio, television, refrigerator, bicycle, motor cycle, car, boat, mobile phone, livestock including chickens, pigs, cows, and goats. They were also asked about the materials used in the construction of the roof, walls, and floor of their homes, whether or not they had access to electricity in the home, and whether or not they had received social assistance (in cash or in kind). Responses were combined into a single index using principal components analysis.	The score of the first principal component was standardized with the resulting variable having a mean of zero and a standard deviation of one.
ECED quality	Each center was assessed by two raters on a 7-point Likert scale, which ranges from 1 = inadequate, 3 = minimal, 5 = good, to 7 = excellent. Seven subscales make up the ECERS-R: Space and furnishing, personal care and routine, language reasoning, activities, interactions, program structure, parents and staff.	The total ECERS-R is the average score of the subscales.

Appendix C. Supplementary analysis for selection into duration of ECED service

In addition to the sequence of ECED service, we also know the months of attendance in each type of ECED service, which allows us to create a variable for duration. Duration was categorized into three groups: less than one year, between one and two years, and greater than or equal to two years.

For ECED duration, the majority of children (71.0 percent) attended playgroup for less than one year. 17.2 percent attended playgroup for one to two years and only 11.7 percent attended for two years or more. In comparison to playgroup, the average duration of attendance in kindergarten was slightly longer. 51.8 percent of children attended for less than one year, 26.5 percent attended between one and two years, and 21.8 percent attended for two years or more.

In Appendix [Table C1](#) below, we show the results of a multinomial logistic regression as presented in Eq. (1). We estimate who selects into different ECED duration by running separate regressions for playgroup and kindergarten duration. For each regression, the base category was enrollment between one and two years.

We found that age was a significant predictor of duration in both cases. Older children were more likely to have enrolled in playgroup for less than one year and were less likely to have enrolled for two years or more of playgroup relative to the base category. For duration in kindergarten, we found slightly different results. The relative risk ratios for age are 0.9 for less than one year of kindergarten and for two years or more of kindergarten. This suggests older children are more likely to have enrolled in kindergarten for 1–2 years (the base category). As before, these findings are consistent with expectations given that kindergarten is meant for older children.

For household level characteristics, we found that children whose mothers were more educated were equally likely to enroll in playgroup for at least two years (as shown by the relative risk ratio of 1.0 for mother's education). Those with better parenting behavior were more slightly likely to enroll in playgroup for at least two years (as shown by the relative risk ratio of 1.1 for parenting quality). We found similar results for duration in kindergarten. A one year increase in a mothers' education was associated with a 1.1 times increase in the likelihood of the child enrolling in two or more years of kindergarten and a one standard deviation increase in parenting quality increased the chances of enrolling in kindergarten for at least two years also by a factor of 1.1.

The results showed that children were more likely to enroll in playgroup and in kindergarten for one to two years and less likely to enroll for less than one year if they lived in villages where the quality of ECED services was in the top tercile (compared to if the quality was in the bottom tercile). However, better ECED quality did not significantly increase the likelihood of children enrolling in playgroup or in kindergarten for two years or more. In terms of ECED fees, we found that as the amount of fees children faced increased from none to more than 10,000 Indonesian rupiah per month, the likelihood of enrolling in early education for one to two years was significantly greater than enrolling for two years or more. Thus, our

Table C1
Multinomial logistic regression of ECED duration.

	Duration in playgroup (base: 1 to 2 years)		Duration in kindergarten (base: 1 to 2 years)	
	< 1 year	≥ 2 years	< 1 year	≥ 2 years
<i>Child characteristics</i>				
Age	1.197*** (0.0383)	0.801*** (0.0333)	0.940** (0.0285)	0.890*** (0.0275)
Girl	0.898** (0.0415)	1.117* (0.0738)	0.897** (0.0393)	1.049 (0.0545)
Stunted	0.795*** (0.0585)	1.182* (0.104)	0.795*** (0.0567)	1.015 (0.0741)
<i>Household characteristics</i>				
Wealth Z-score	0.839*** (0.0379)	0.823*** (0.0441)	0.576*** (0.0318)	0.985 (0.0568)
Mother's education (years)	0.959*** (0.0117)	1.031** (0.0158)	0.877*** (0.0124)	1.054*** (0.0152)
Parenting practices	1.007 (0.0299)	1.108*** (0.0437)	0.990 (0.0288)	1.139*** (0.0340)
<i>Village characteristics</i>				
ECED quality (base: Bottom tercile)				
Middle tercile	1.042 (0.157)	1.234 (0.181)	1.157 (0.214)	1.222 (0.213)
Top tercile	0.753** (0.108)	1.194 (0.164)	0.748* (0.129)	1.145 (0.192)
ECED fees (base: No fees)				
≤ 10,000 IDR	0.596*** (0.0963)	0.853 (0.126)	0.713 (0.166)	0.827 (0.144)
> 10,000 IDR	0.649*** (0.109)	0.657*** (0.105)	0.537*** (0.126)	0.715* (0.124)
Constant	2.628*** (0.831)	2.865*** (1.003)	14.69*** (5.110)	1.388 (0.451)
Observations	12,710		12,710	

Note: Exponentiated coefficients. Standard errors clustered at the village level in parentheses.

*** p < 0.01, ** p < 0.05, * p < 0.1.

findings suggest that parents make decisions about how long to enroll their children in early education based in part on the characteristics of the services in their village. Families were more likely to enroll their children in early education for at least one academic year if the quality of the service was high. In addition, they were less likely to enroll their children in early education for two academic years or more if the monthly fee exceeded 10,000 Indonesian rupiahs.

Appendix D. Supplementary analysis for association between ECED pathway and test scores in primary school

We re-estimated equation (2) by adding a vector of variables for the duration of enrolment ($Duration_{ij}$) in playgroups and kindergartens (see Appendix 3 for summary statistics of duration). In doing so we were not only interested in the magnitude and direction of the coefficients of $Duration_{ij}$ but also in how the coefficients of $Sequence_{ij}$ changed. Results for this model specification are presented below in Appendix Table D1

In Appendix Table D1, we controlled for the duration of enrolment in playgroups and kindergartens.¹⁰ For language test scores, we no longer found that children who enrolled in playgroup at age 3–4 then kindergarten at age 5–6 perform significantly better than their peers who only enrolled in kindergarten at age 5–6. In contrast, for math test scores, we continued to find that children who enrolled in a sequence of playgroup and kindergarten at developmentally appropriate ages yielded significantly higher test scores than their peers who enrolled in other early education pathways (approximately 0.2 standard deviations as before). It is worth noting that once we controlled for duration of ECED in addition to sequence, the magnitude of the coefficient for playgroup at age 3–4 then kindergarten at age 5–6 dropped for all subjects (in the case of language the point estimate dropped from 0.4 to 0.3 and in the case of mathematics it dropped from 0.5 to 0.2 and in the case of cognitive skills from 0.2 to a statistically insignificant 0.04). Meanwhile, the coefficients on duration of playgroup and kindergarten showed significantly higher test scores (on average) for those who enrolled for at least two years compared to those who only enrolled for one to two years. This suggests that over and above enrolling in ECED services in the right sequence at the intended ages, the duration of enrollment in playgroups and kindergartens is a significant predictor of children's subsequent learning outcomes in primary school.

We did not find significant results for general cognitive skills. The divergent results of the general cognitive skills compared to the language and math results may be explained by the fact that the items in the language and math assessments were pooled from a battery of questions that align with the national curriculum for lower primary school grades while the general cognitive items are based on the Raven's Colored Progressive Matrices. The matrices measure abstract reasoning and can be regarded as a non-verbal estimate of fluid intelligence. While we would have hoped that participation in ECED services would have shown enhancement of general cognitive skills, none of the programs included specific educational

¹⁰ If age cut-offs of admission were strictly enforced duration and timing would likely be highly correlated. However, in Indonesia, age cut-offs are rarely strictly enforced.

Table D1
Association of ECED sequence and duration and test scores in primary school.

	Duration		
	Language	Maths	Cognitive Skills
	(1)	(2)	(3)
Sequence (Base: No ECED [I])			
Playgroup (3-4) then primary [II]	−0.122* (0.0633)	−0.0119 (0.0659)	−0.0158 (0.0762)
Kindergarten (5-6) then primary [III]	0.216** (0.0968)	0.0822 (0.109)	0.0116 (0.124)
Playgroup (3-4) then kindergarten (5-6) then primary [IV]	0.277** (0.108)	0.238** (0.119)	0.0387 (0.138)
Other combination [V]	0.399** (0.175)	0.247 (0.198)	0.0668 (0.246)
Playgroup (5-6) then primary [VI]	−0.115* (0.0601)	−0.0135 (0.0631)	−0.0664 (0.0745)
Playgroup (5) then kindergarten (6) then primary [VII]	0.231* (0.126)	0.167 (0.134)	0.000588 (0.157)
Duration (Base: 1- 2 years)			
Playgroup: < 1 year	−0.114** (0.0552)	−0.0405 (0.058)	−0.0444 (0.0693)
Playgroup: ≥ 2 years	0.140*** (0.0324)	0.128*** (0.0319)	0.0553 (0.0379)
Kindergarten: < 1 year	0.0198 (0.0962)	−0.102 (0.109)	−0.0999 (0.123)
Kindergarten: ≥ 2 years	0.0925*** (0.0219)	0.0857*** (0.022)	0.0511* (0.0274)
Constant	−0.461*** (0.114)	−0.366*** (0.125)	−0.206 (0.144)
Observations	12,710	12,710	12,710
R-squared	0.284	0.235	0.109
Timing:			
[II] - [I]	−0.122*	−0.0119	−0.0158
[VI] - [II]	0.00669	−0.00153	−0.0506
[III] - [II]	0.338***	0.0941	0.0273
[IV] - [III]	0.0609	0.156***	0.0271
[VII] - [IV]	−0.0452	−0.071	−0.0381

Note: Robust standard errors clustered at the village level in parentheses. All regressions include child characteristics (age, grade, gender, and stunting), family characteristics (household wealth, mother's education, parenting practices), ECED characteristics (average quality, average fees), and district fixed effects.

*** p < 0.01, ** p < 0.05, * p < 0.1.

activities to enhance such skills, such as working memory games. Instead the ECED services in Indonesia exposed children to the basics of language and mathematical concepts to prepare them for primary school, in a manner aligned with the national early learning curriculum.

Thus, over and above sequence of ECED, we found that duration of early education was a significant predictor of children's math test scores in primary school, as those who enrolled in at least two years of playgroup and kindergarten scored significantly better than their peers who enrolled for shorter periods of time.

Appendix E. Sensitivity of illustrative cost-effectiveness estimates to omitted variable bias

In this section, we analyze the coefficient stability of the effectiveness estimates used in our illustrative cost-effectiveness figures. Effectiveness is estimated by regressing primary school test scores on a categorical variable of early childhood education pathways. The categories are no ECED (reference category), some ECED (enrollment in only playgroup, only kindergarten, or a combination of playgroup and kindergarten but at later ages than developmentally appropriate), and “ideal” ECED (enrollment in playgroup at ages 3–4 then kindergarten at ages 5–6 then primary). Results are shown in Table E1 with Panel A for language test score and Panel B for math test scores. Column 1 presents the coefficients, standard errors, and R-squared from the baseline regression of test scores on early childhood education pathway. Column 2 shows similar values with a full set of controls for child characteristics (age, grade, gender, and stunting), household characteristics (household wealth, mother's education, parenting practices), and village characteristics (average ECED quality and fees). In both the baseline and control regressions, enrollment in some ECED or the ideal ECED sequence is associated with higher language test scores, relative to those never enrolled. Including the full set of controls reduces the point estimates and increases the R-squared appreciably, suggesting that there is considerable selection into early childhood education pathways and that the controls included are informative of this selection bias.

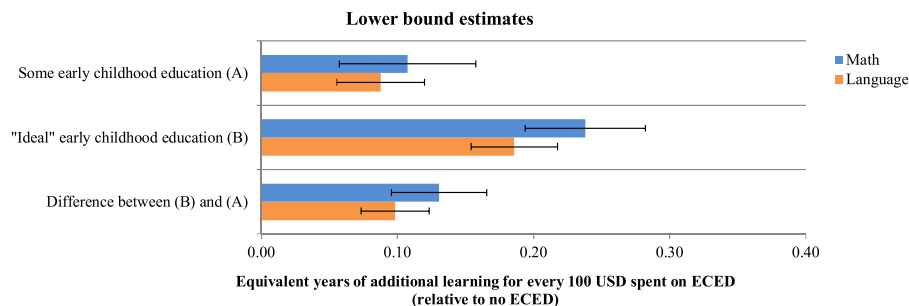
Column 3 reports the adjusted coefficient using the approach in Oster (2017). This method computes a lower bound coefficient estimate (β^*) by taking into account the changes in both coefficients and R-squared when control variables are included to the baseline regression model. A key assumption of this method is that the relationship between the coefficient of interest and unobservables can be recovered from the observed relationship between the coefficient of interest and observable controls. To compute this lower bound coefficient, we assume that the R-squared (R_{max}) is scaled up by a factor of $\Pi = 1.3$. We also assume $\delta = 1$, which means that the unobservables are at least as informative as the observables. To

Table E1

Robustness of association between primary school test scores and early childhood education pathways.

	(1)			(2)			(3)		(4)	(5)
	Baseline			Control			Adjusted		Identified Set	$\tilde{\delta}$ for $\beta = 0$
	Coef ($\hat{\beta}$)	Std Error	R-sq (\hat{R})	Coef ($\tilde{\beta}$)	Std Error	R-sq (\tilde{R})	Coef (β^*)	Std Error		
Panel A: Language test z-score ($R_{max} = .369$)										
(base category: No ECED)										
Some ECED	0.324***	0.039	0.030	0.174***	0.031	0.277	0.112***	0.021	[0.112, 0.174]	2.574
Ideal ECED	0.517***	0.056	0.030	0.407***	0.046	0.277	0.356***	0.031	[0.356, 0.407]	5.238
Panel B: Math test z-score ($R_{max} = .307$)										
(base category: No ECED)										
Some ECED	0.331***	0.038	0.038	0.174***	0.032	0.231	0.105***	0.025	[0.105, 0.174]	2.334
Ideal ECED	0.562***	0.053	0.038	0.419***	0.046	0.231	0.349***	0.033	[0.349, 0.419]	4.152

Note: (1) “Baseline” is the regression of test scores on a categorical variable of early childhood education pathway. The categories are no ECED, some ECED (enrolled in only playgroup, only kindergarten, or a combination of playgroup and kindergarten but at later ages than developmentally appropriate), ideal ECED (enrolled in playgroup at ages 3–4 then kindergarten at ages 5–6 then primary). (2) “Control” is the regression of test scores on a categorical variable of early childhood education pathways with a full set of controls: child characteristics (age, grade, gender, and stunting), household characteristics (household wealth, mother’s education, parenting practices), and village characteristics (average ECED quality and fees). (3) “Adjusted” estimates compute the coefficient of interest β^* based on $R_{max} = 1.3\tilde{R}$ and $\tilde{\delta} = 1$. Standard errors around β^* are generated using a bootstrap approach. (4) The identified set of β is bounded above by $\tilde{\beta}$ and below by β^* . (5) $\tilde{\delta}$ is the value for which $\beta = 0$ for a given value for $R_{max} = 1.3\tilde{R}$. A value of $\tilde{\delta} = 1$ means that the unobservables are at least as important as the observables included as controls. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

**Fig. E1.** Cost-effectiveness estimates using lower-bound effectiveness estimates.

compute the standard errors around the coefficient, we use a bootstrap approach. For both language and test score outcomes, the lower-bound estimates for “some” and “ideal” ECED are positive and significant at the $p < 0.01$ level.

The identified set in column 4 brings together the results from columns 2 (upper bound) and columns 3 (lower bound). For both outcomes, the bounds for the coefficients do not include zero, suggesting that unobservables are unlikely to change our finding that enrolling in ECED pathways at developmentally-appropriate ages is associated with higher primary school test scores. Another way of presenting the sensitivity analysis is to calculate a value of δ that would yield a coefficient estimate of zero (column 5). In order to bring down the coefficient estimates to zero, the unobservables would need to be between 2.3 and 2.6 times (for the “some ECED” category) and between 4.2 and 5.2 times (for the “ideal ECED” category) more important than the full set of child-, family-, and village-level controls we included in our regression model. Taken together, the results presented in Appendix Table E1 suggest that our effectiveness estimates are robust to omitted variable bias.

Appendix Fig. E1 shows the illustrative cost-effectiveness using the lower-bound estimates computed using Oster’s (2017) bounding approach. Enrollment in the full sequence of playgroup and kindergarten at developmentally-appropriate ages is associated with an additional 0.19 years of learning in language and 0.24 years of learning in math for every 100 USD invested in early childhood education. In contrast, enrollment in some ECED – collapsing together children who attended only playgroup, only kindergarten, or a combination of playgroup and kindergarten at later ages – is only associated with an additional 0.09 years of learning in language and 0.11 years of learning in math for every 100 USD invested in early education. Furthermore, the difference in additional learning for a full sequence of ECED at the appropriate ages and for some ECED is practically and statistically significant at the $p < 0.01$ level.

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